Center Innovation Fund: MSFC CIF

Damage-Tolerant, Lightweight, High-Temperature Radiator for Nuclear Powered Spacecraft

Completed Technology Project (2012 - 2012)

Project Introduction

Game-changing propulsion systems are often enabled by novel designs using advanced materials. Radiator performance dictates power output for nuclear electric propulsion (NEP) systems. A model developed at UMass showed that use of novel materials and designs for a high-temperature radiator for space-based power systems can dramatically improve the power per weight and weight per area.

Advanced propulsion technologies such as Nuclear Electric Propulsion (NEP) have been partially limited by the mass of thermal rejection systems. NEP was proposed for the Jupiter Icy Moons Obiter (JIMO). Use of novel, lightweight, high-temperature radiator materials, such as those which will be studied in the proposed effort could greatly reduce the mass required for the radiators and help enable NASA exploration missions like JIMO using NEP or other advanced propulsion technologies. Other areas that would potentially benefit from the results of this work include spacecraft heat rejection systems and surface nuclear power. Graphene is a two-dimensional atomic-scale honeycomb lattice made of carbon atoms. This same honeycomb lattice is the basic structural element of carbon nanotubes (CNT) and carbon fibers. While high-quality graphene films are only available in atomic-scale thicknesses, high-conductivity carbon fibers and woven cloth made from CNTs are available commercially in quantity. A novel aspect of the proposed effort is to use graphene-based materials including both high-conductivity carbon fibers and CNT cloth in radiator applications in order to take advantage of several key properties of these materials: low density, high thermal conductivity and anisotropic heat transfer. Modeling results show that a carbon-fiber-based radiator can provide a ten-fold improvement in heat transfer per unit mass compared to the current state-of-the-art molybdenum-based high-temperature radiators. The heat pipe simulator developed in Phase 1 of this effort will be used for testing. A heater is used to simulate the heat pipe envisioned in space. A test article fabricated using the material to be studied is secured to the heater and placed in chamber and heated to the test temperature in a vacuum of about 10-6 Torr.Temperatures in the range of 400 – 600 ºC were tested. Optical diagnostics provide temperature data, including pyrometry and thermal imaging.

Anticipated Benefits

It will provide a more detailed, predictive modeling capability in order to help guide design efforts for radiators

Project Image Damage-Tolerant, Lightweight, High-Temperature Radiator for Nuclear Powered Spacecraft

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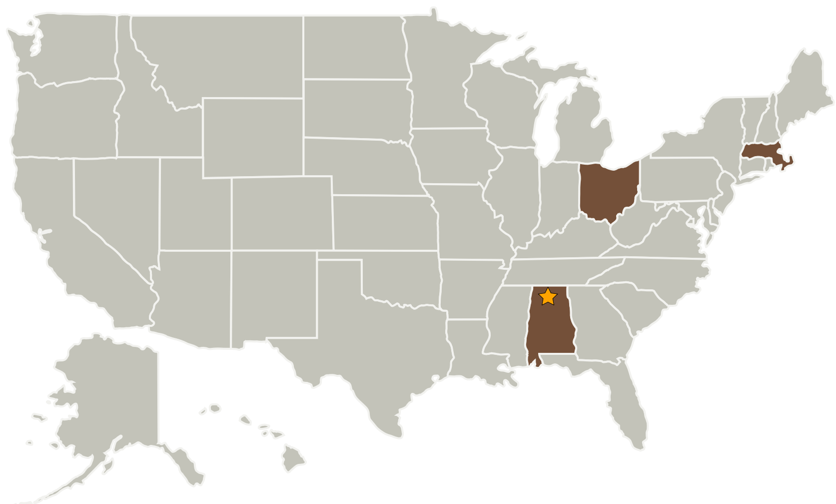
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Marshall Space Flight Center(MSFC)	Lead Organization	NASA Center	Huntsville, Alabama
Jacobs Engineering Group, Inc.	Supporting Organization	Industry	Dallas, Texas

Co-Funding Partners	Type	Location
University of Massachusetts-Amherst(UMASS)	Academia	Amherst, Massachusetts

Primary U.S. Work Locations	
Alabama	Massachusetts
Ohio	

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Marshall Space Flight Center (MSFC)

Responsible Program:

Center Innovation Fund: MSFC CIF

Project Management

Program Director:

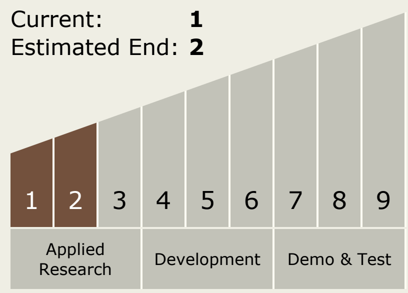
Michael R Lapointe

Program Manager:

John W Dankanich

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



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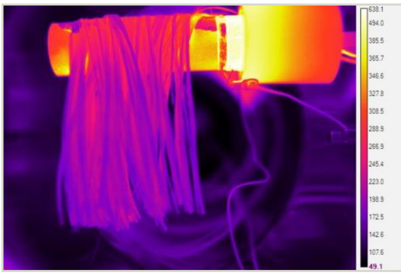
Images



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Project Image Damage-Tolerant, Lightweight, High-Temperature Radiator for Nuclear Powered Spacecraft
(https://techport.nasa.gov/image/1185)

Technology Areas

Primary:

- TX14 Thermal Management Systems
  └ TX14.2 Thermal Control Components and Systems
    └ TX14.2.3 Heat Rejection and Storage